Influence of Landscape Restoration and Degradation on Storm Surge and Waves

Planning Community of Practice Conference 2008

Ty Wamsley, Mary Cialone, Barbara Kleiss, and Jane Smith

USACE Engineer Research and Development Center

Objective

- Demonstrate how a numerical modeling system can be applied to address planning challenges related coastal storm damage reduction projects and changing coastal landscapes.
  - Changing Landscape: Erosion, subsidence, sea level rise, sediment supply, habitat switching, etc….
  - Mainland coast, barrier islands, wetlands

Storm Surge and Wetlands

- Complicated Dynamics preclude application of simple “rules of thumb” (i.e. X miles of marsh reduces surge by Y feet – the old way of doing things)
  - Storm track
  - Storm intensity
  - Surrounding topography/bathymetry
  - Vegetation type

- Modeling is a tool for qualitative and/or semi-quantitative evaluation of the surge/wave reduction potential of coastal landscape features.

- Model is valuable for identifying trends and evaluating the relative performance of different features or alternatives

Storm Surge and Wetlands

Why the limitations?

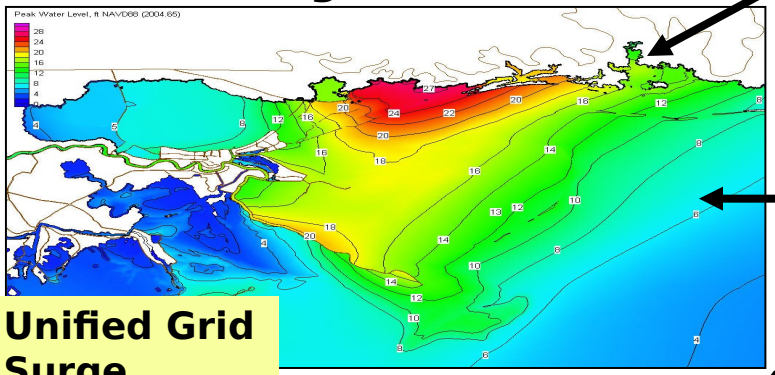
- New application of the model and area of active research.
  - Complicated physics
  - Representation of physical system
  - Friction factors
- Very limited data.
  - Need to fund research for field and laboratory studies

Modeling System

- IPET
- FEMA
- LaCPR
- MsCIP

- Extensively reviewed - including the National Academy of Sciences

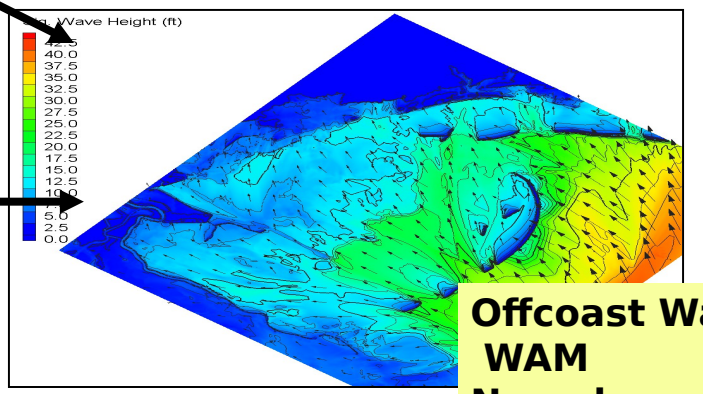
Surge Model



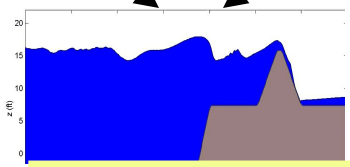
Unified Grid Surge model: ADCIRC

Coupling

Wave Models

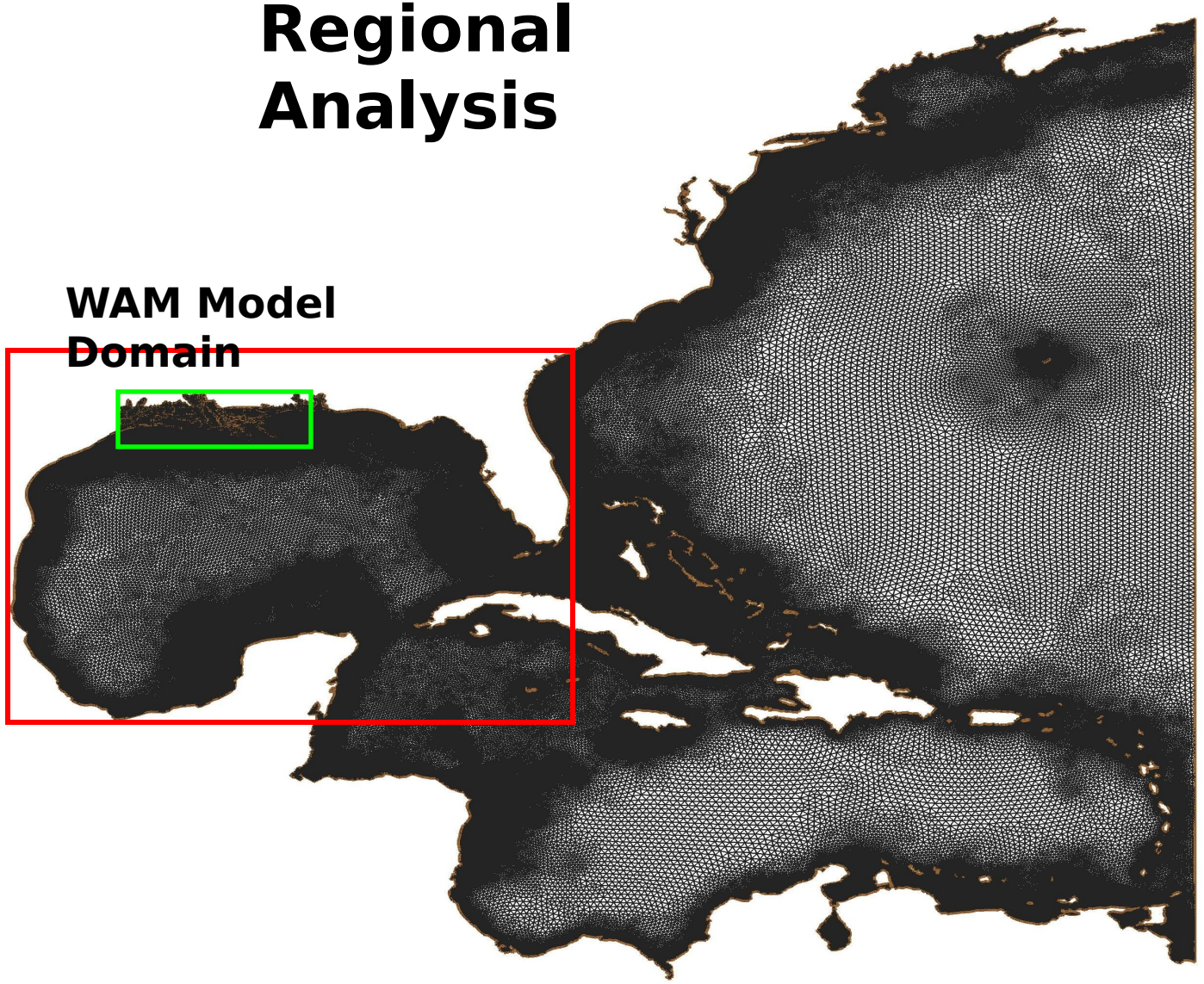


Offcoast Waves: WAM
Nearshore Waves: STWAVE

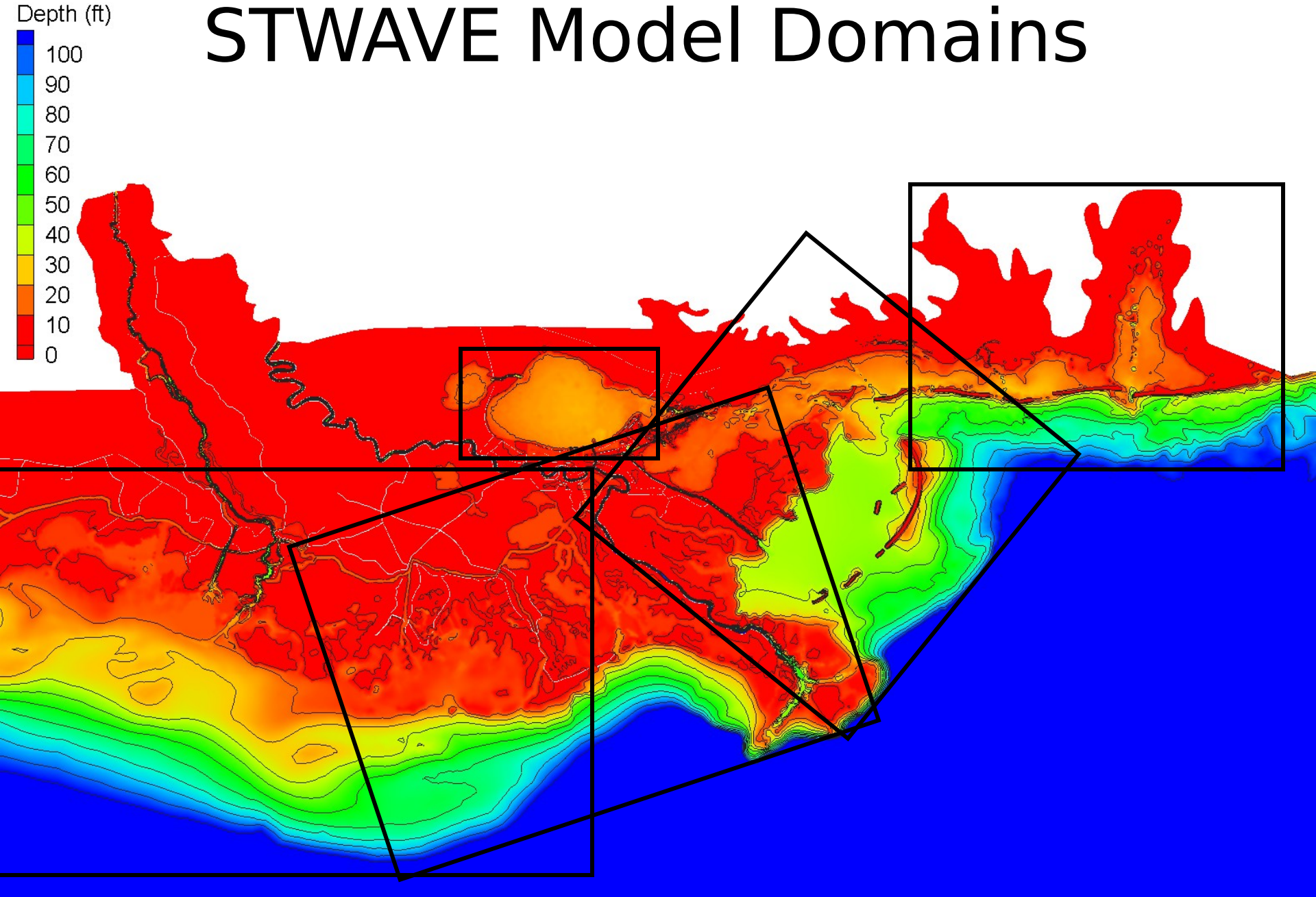


Local Scale Waves: Boussinesq - Parametric

ADCIRC Grid Domain



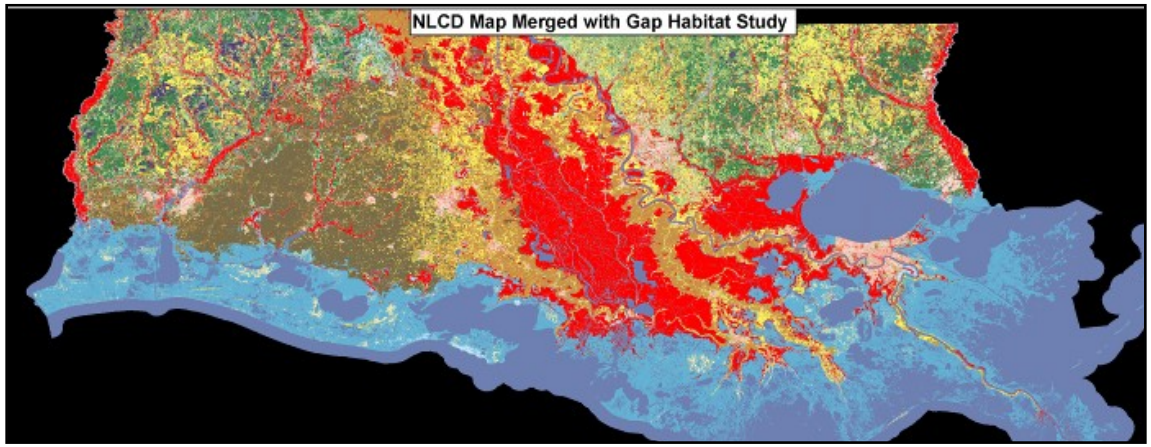
STWAVE Model Domains



Storm Surge and Landscape Features

- Considered:
  - Bathymetry and topography modify storm surge and waves.
  - Vegetation (land cover) reduces surface winds and slows surge propagation .
- Not Considered:
  - Changes to the landscape that occur during storms passage (i.e. vegetation stripped, land mass eroded)
  - Changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features

Land Cover Parameterization

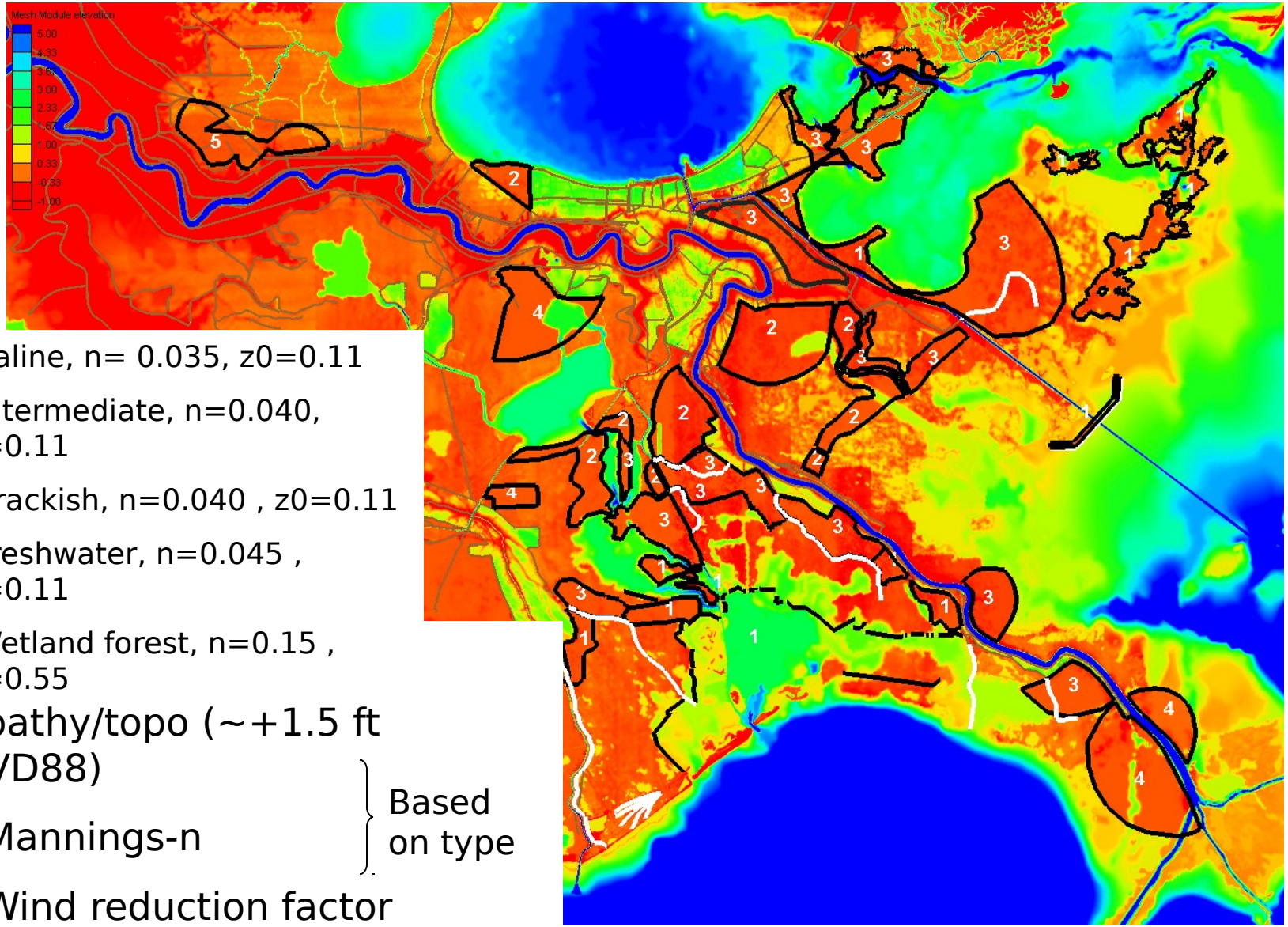


Manning-n values for Louisiana GAP classes:

n = 0.055 ! fresh marsh
n = 0.050 ! intermediate marsh
n = 0.045 ! brackish marsh
n = 0.035 ! saline marsh
n = 0.15 ! wetland forest - mixed
n = 0.17 ! upland forest - mixed
n = 0.18 ! dense pine thicket
n = 0.020 ! water

- Manning-n scalar parameterization used
  - Defined at appropriate grid scale
  - Base on published values
  - Validated against hindcasts of hurricanes Katrina and Rita

Restored Landscape



1-Saline, n= 0.035, z0=0.11

2-Intermediate, n=0.040, z0=0.11

3-Brackish, n=0.040 , z0=0.11

4-Freshwater, n=0.045 , z0=0.11

5-Wetland forest, n=0.15 , z0=0.55

- bathy/topo (~+1.5 ft NAVD88)
- Mannings-n
- Wind reduction factor

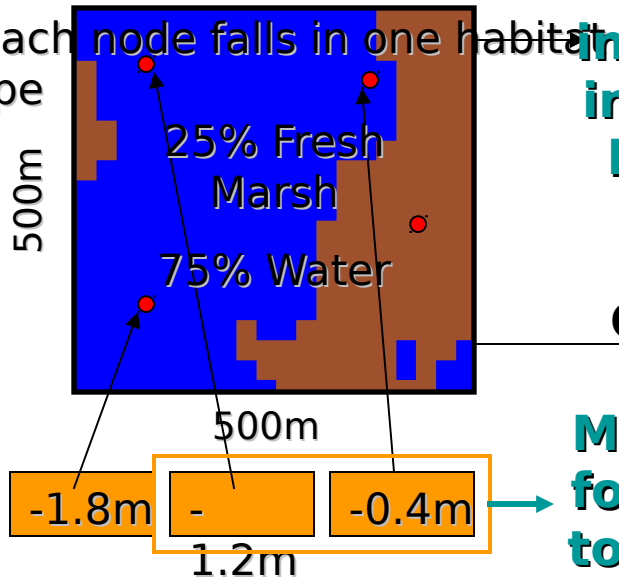
} Based on type

Future Degraded Coastal Landscape
CLEAR Output => ADCIRC

Bathy/Topo/Friction

CLEAR Input Cell Year 0

- LULC Data at 25m Res
- Each node falls in one habitat type



50% increase in Fresh Marsh

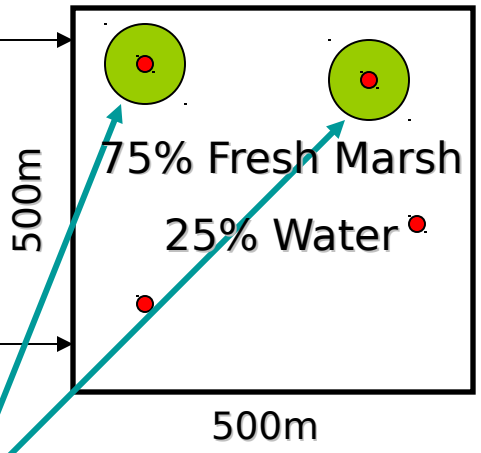
2 water nodes need to change to Fresh Marsh

CLEAR 50 Yr Model Run

Most likely candidates for change from water to fresh marsh as they were the shallowest nodes in Year 0

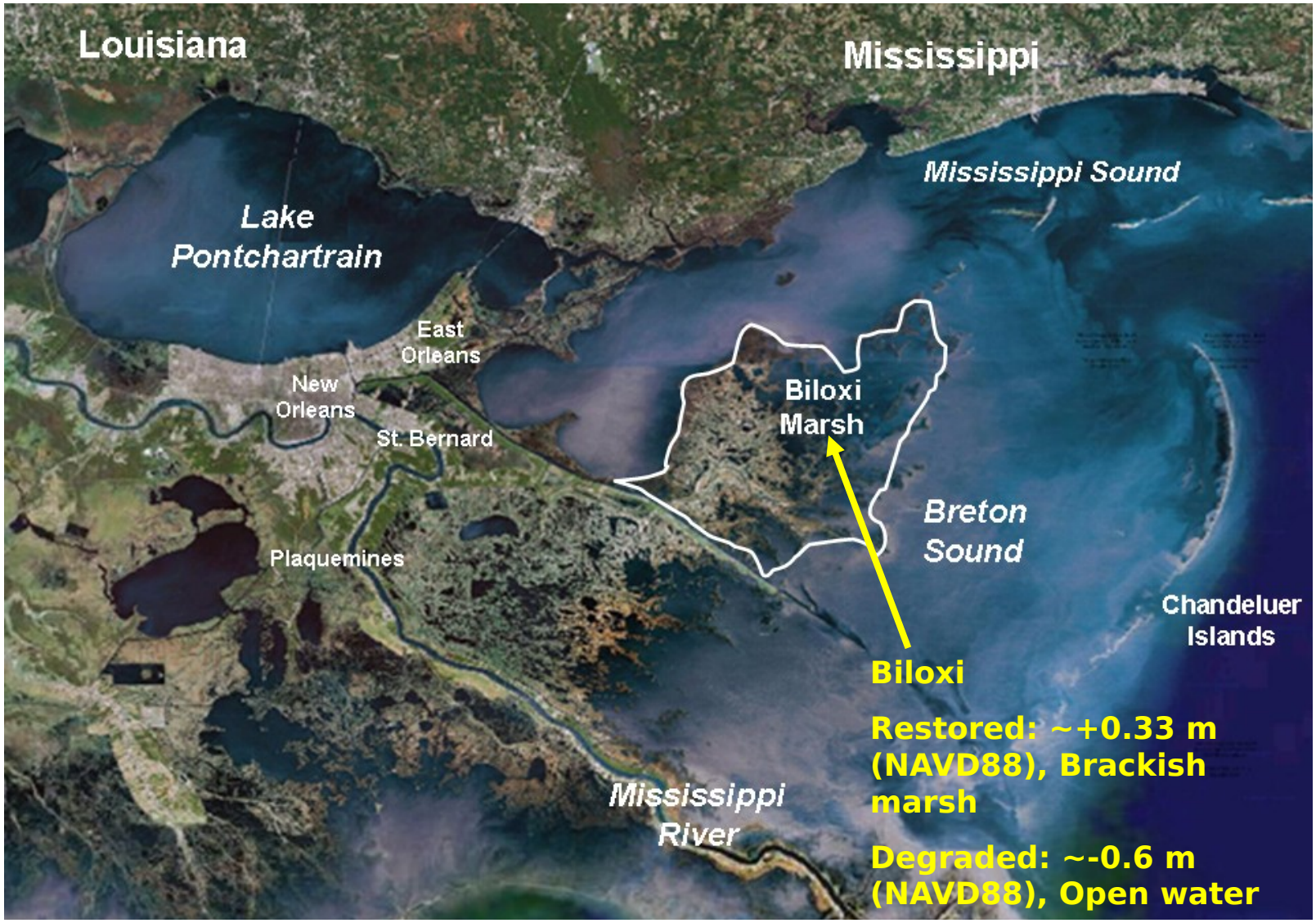
CLEAR Output Cell Year 50

- Spatial uncertainty



CLEAR => Coastal Louisiana Ecosystem Assessment and Restoration

Wetland Restoration/Degradation



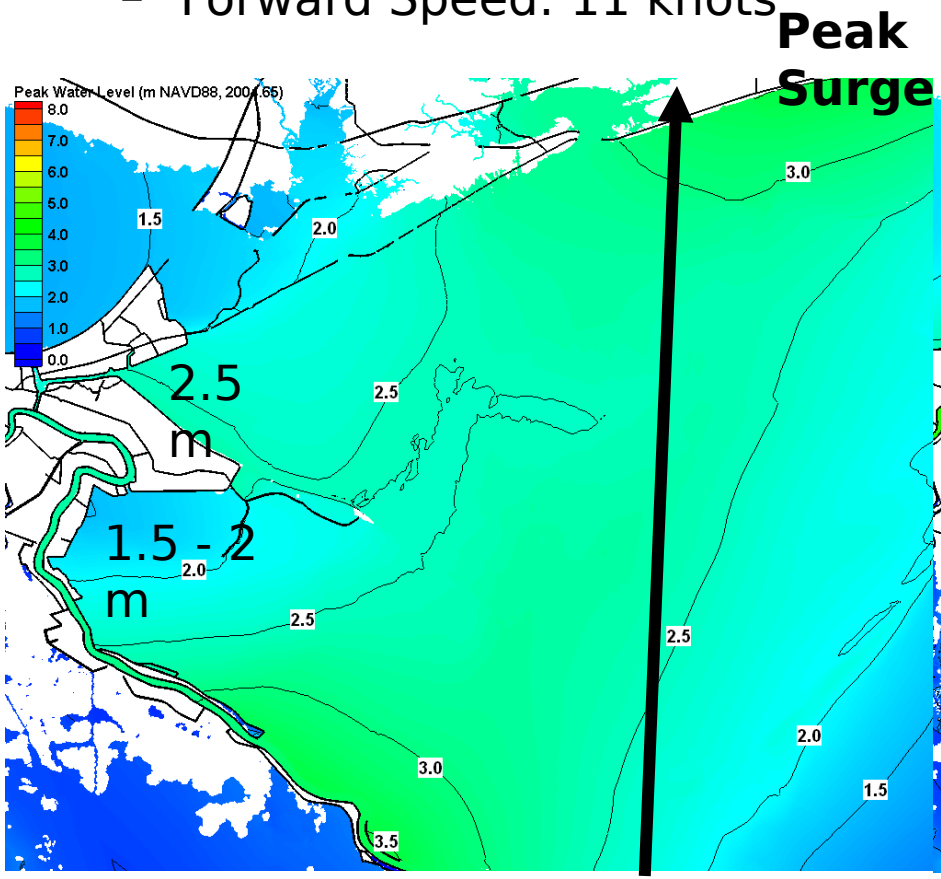
Sensitivity Storms

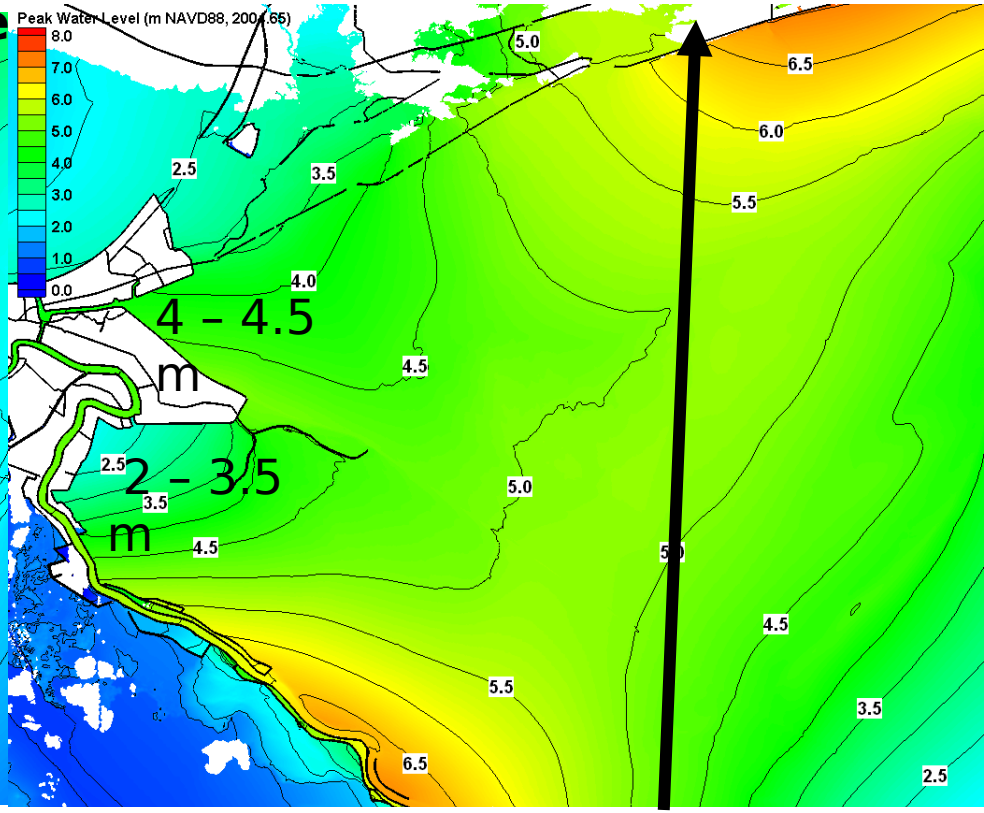
HUR1 (Hurricane Hilda-like)

- Central Pressure: 960 mb
- Rmax: 22 nm
- Forward Speed: 11 knots

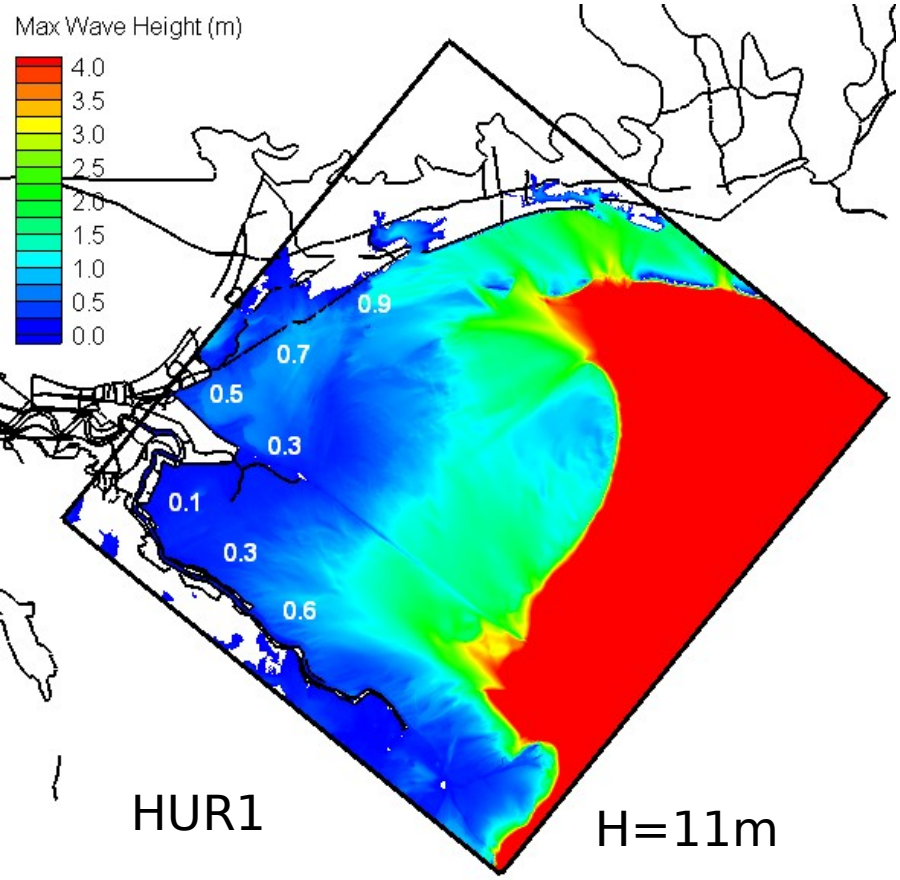
HUR2 (Hurricane Katrina-like)

- **Central Pressure: 900 mb**
- **Rmax: 22 nm**
- **Forward Speed: 11 knots**



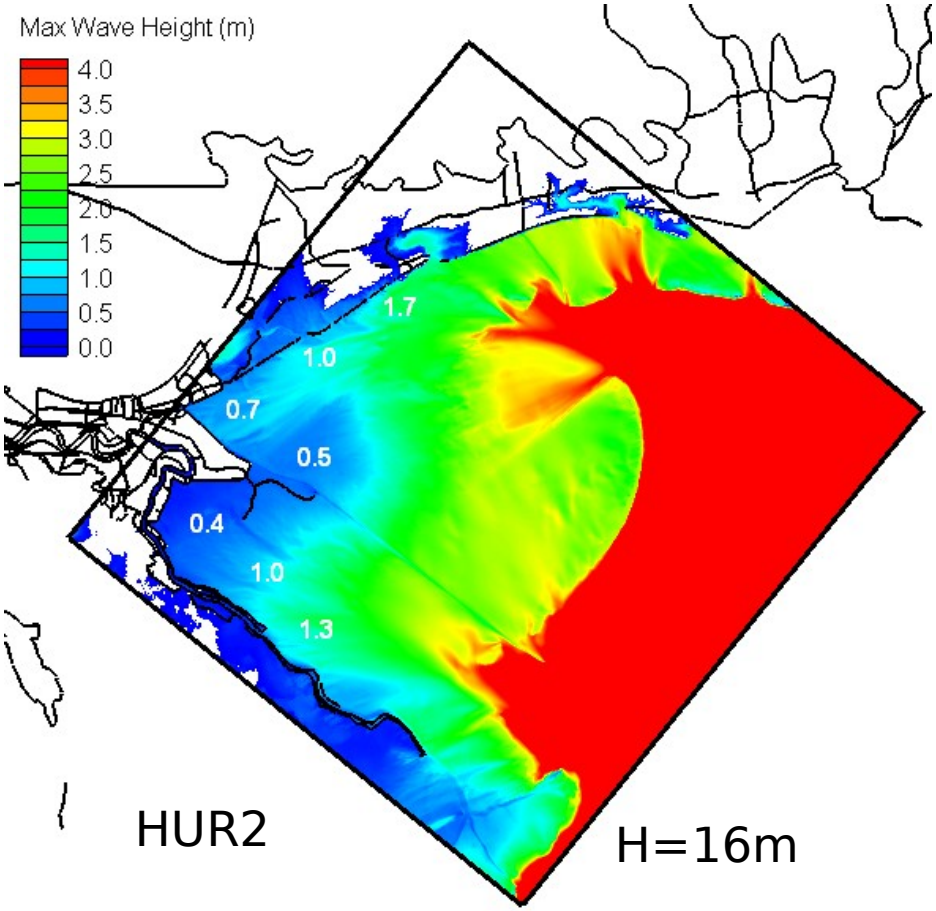


Max Wave Height



HUR1

H=11m

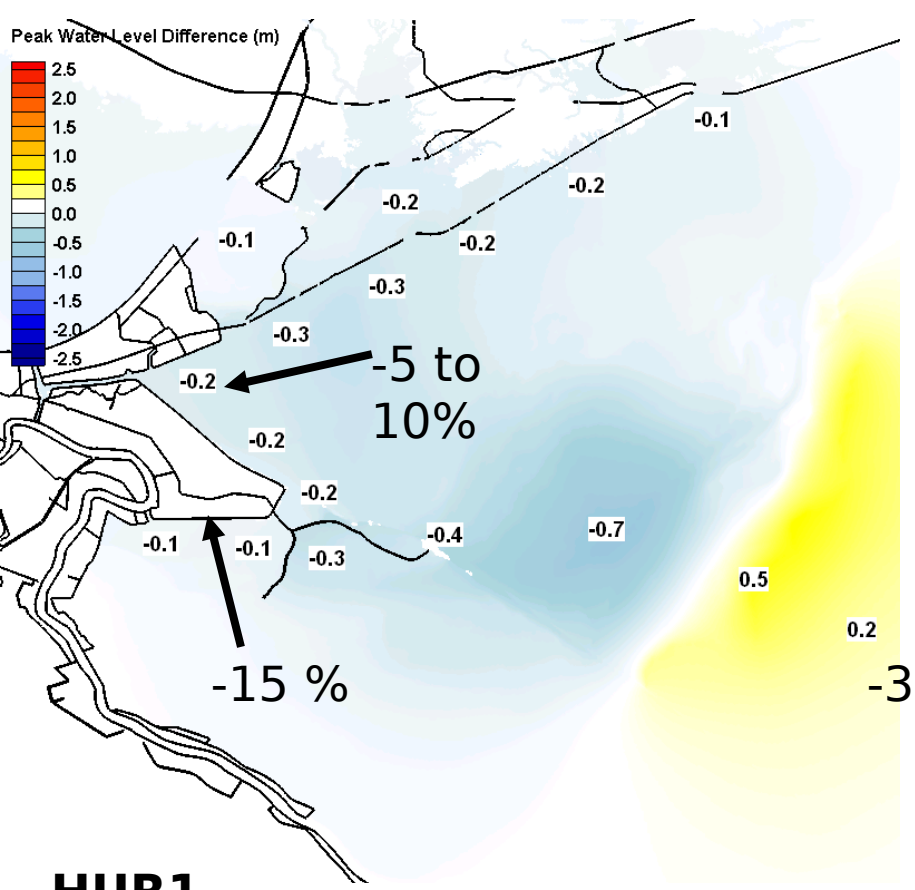


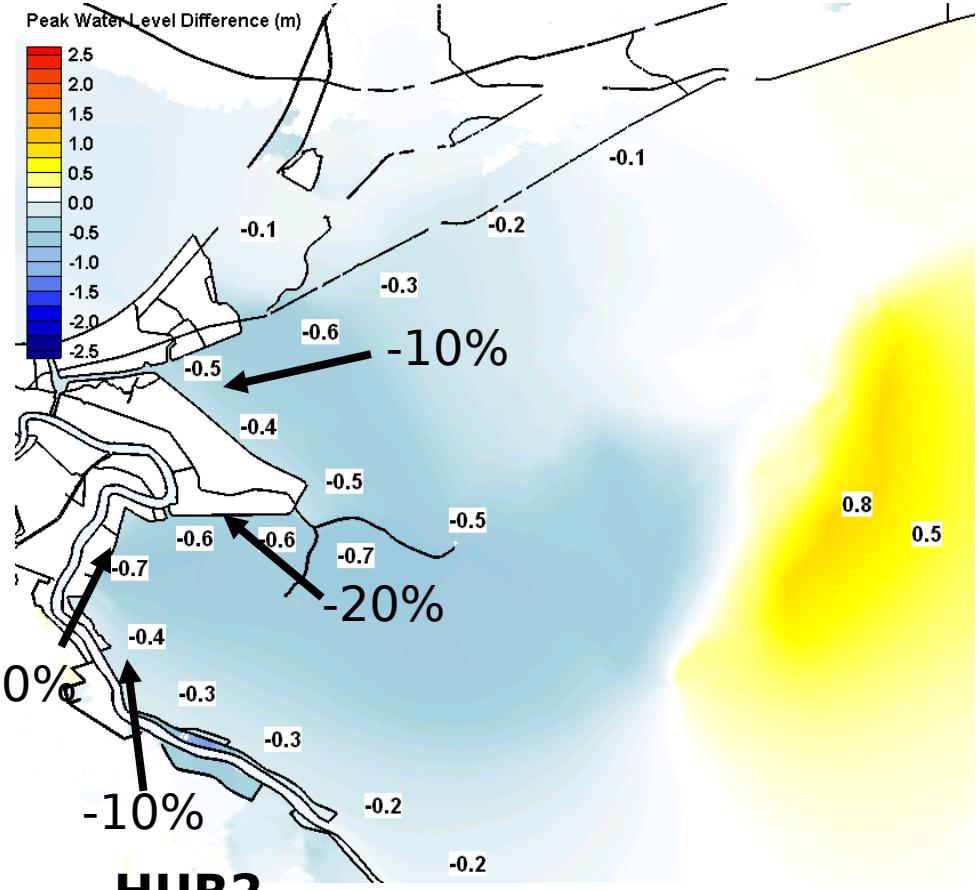
HUR2

H=16m

Biloxi Restoration

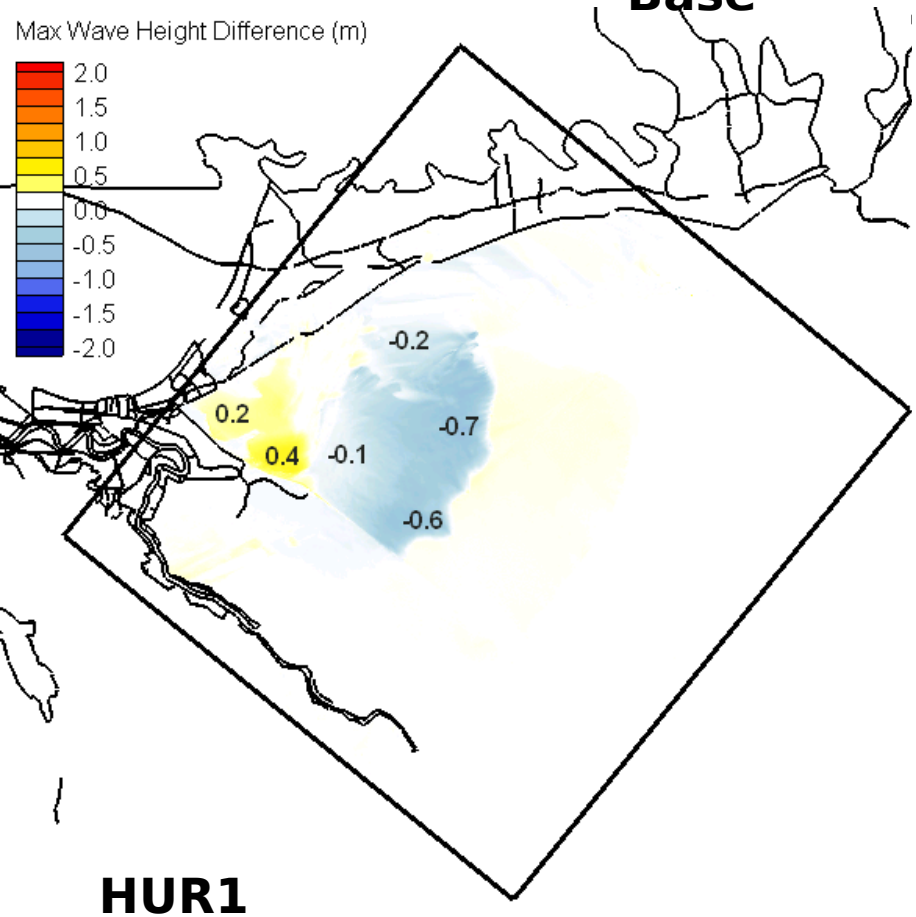
Surge: Restored - Base



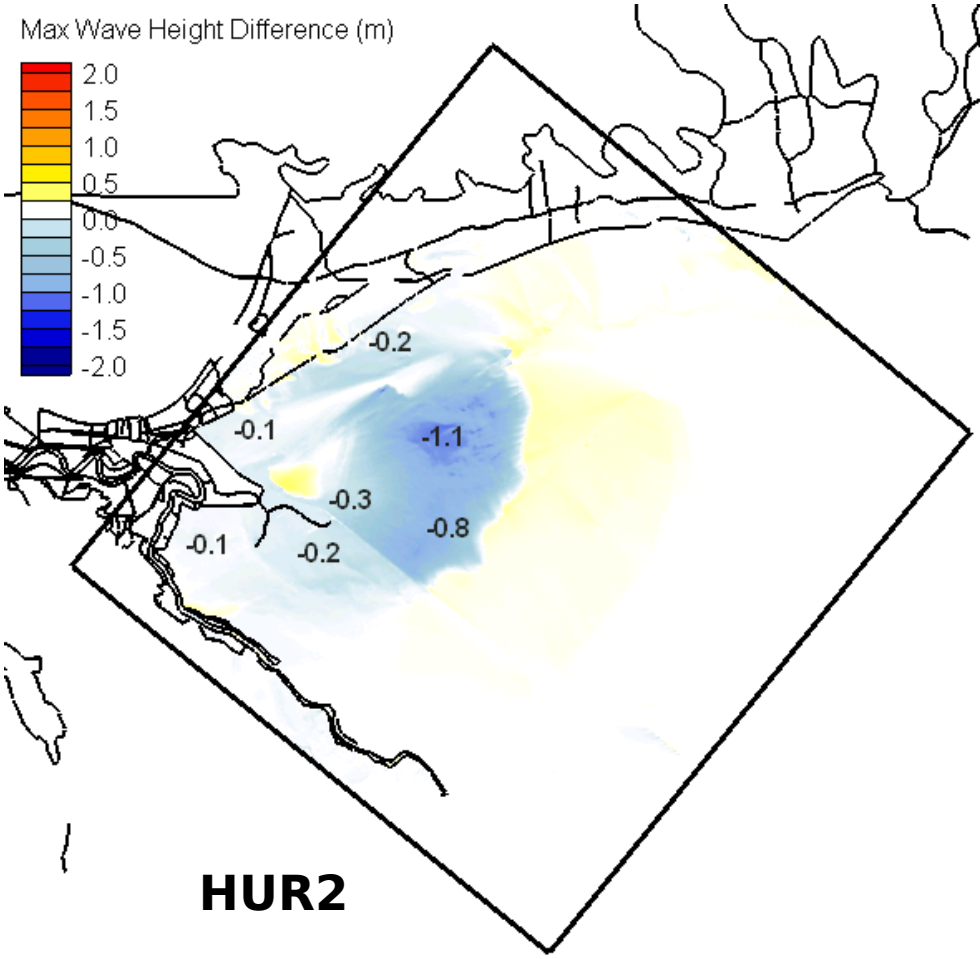


Biloxi Restoration

Waves: Restored - Base



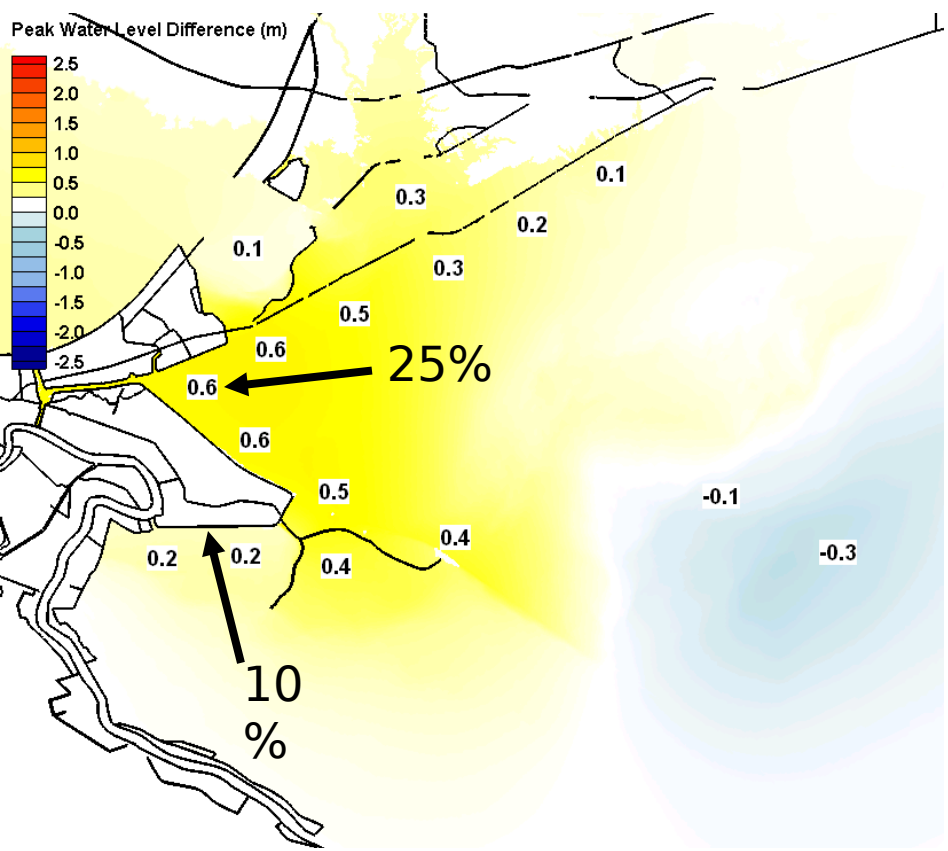
HUR1



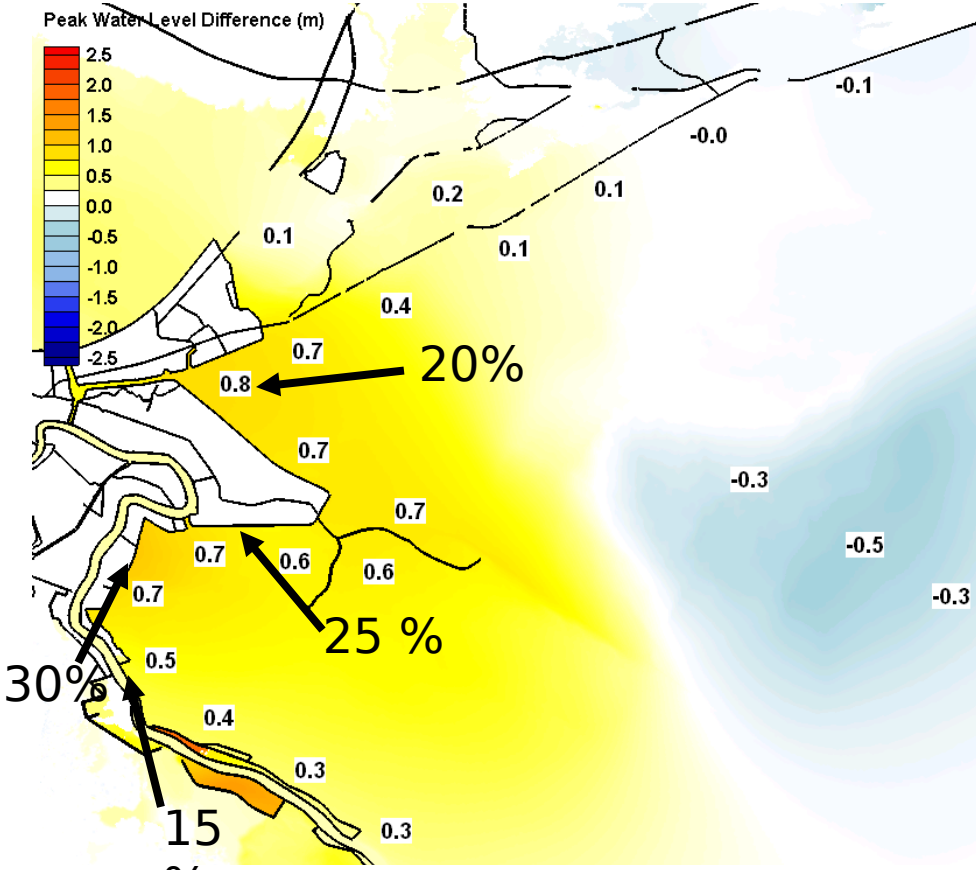
HUR2

Biloxi Degradation

Surge: Degraded - Base



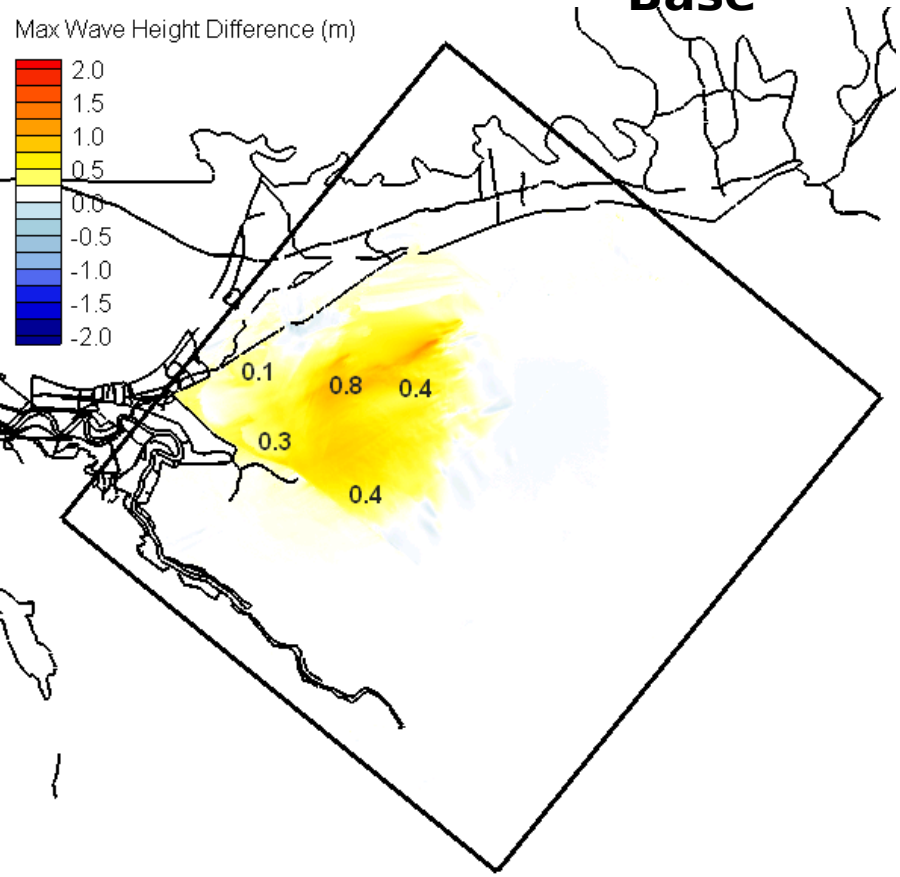
HUR1



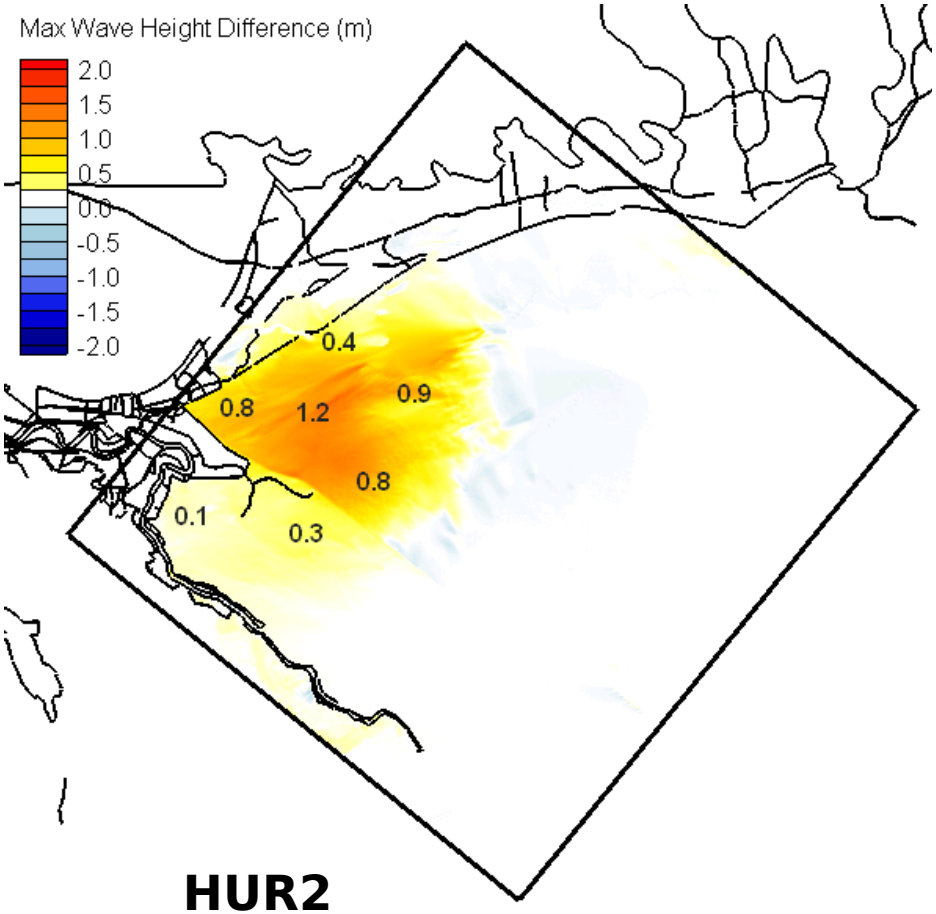
HUR2

Biloxi Degradation

Waves: Degraded - Base



HUR1



HUR2

Key Takeaway Points

- Changing landscapes should be considered in the planning process (i.e. sea level rise, wetland degradation, barrier island deterioration, etc.).
- The modeling system presented can be applied to make valid comparisons of future conditions and alternatives.
- The regional model allows for a “systems analysis” (i.e. unintended consequences far from project site, natural system influences on engineered system, etc.).
- Additional R&D is needed to improve our predictive capabilities.

End